

Description of the COMPASS-U tokamak plasma-facing components (PFC)

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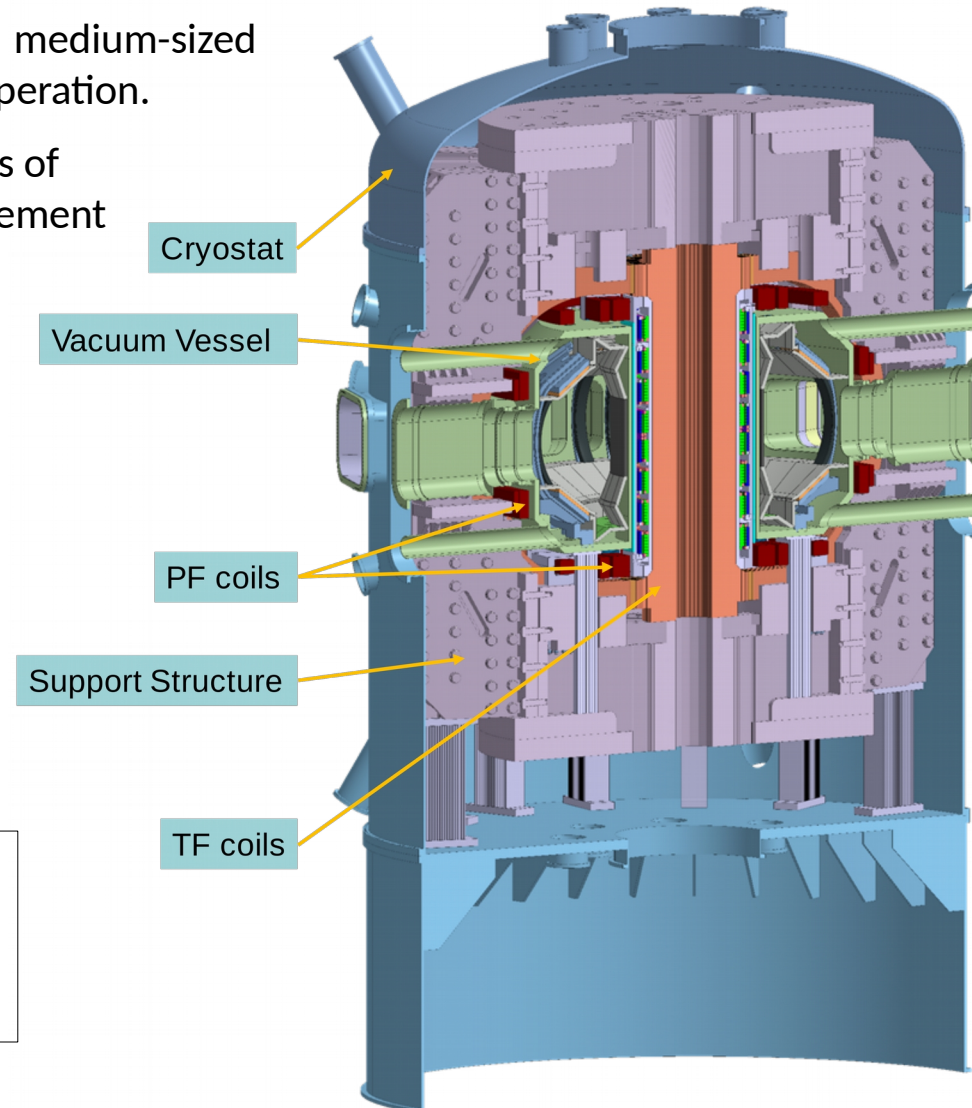
This document is intended for the companies that have shown interest in the Preliminary Market Consultation for COMPASS-U plasma-facing components to initiate discussion, to have feedback on fabrication and viability of the components. It provides very basic information about the components which are still in Design Phase.

- COMPASS-U will be a high magnetic field (5 T) medium-sized tokamak with high wall temperature (<500°C) operation.
- The scientific program is aimed to address topics of plasma exhaust, liquid metals, enhanced confinement modes and edge plasma physics.

Basic dimensions and parameters:

$R = 0.894 \text{ m}$	$T_{\text{flat-top}} = 1-3 \text{ s}$
$a = 0.27 \text{ m}$	$\delta = 0.5$
$B_T = 5 \text{ T}$	$\kappa = 1.8$
$I_p = 2 \text{ MA}$	$V_{\text{Plasma}} \sim 2 \text{ m}^3$

High capability to address the key Plasma Exhaust Physics challenges
→ robust PFC are of high importance



PFC functions:

- Absorb the high heat and particle fluxes from the plasma during operation
- Protect the vacuum vessel and in-vessel components (*diagnostics, RF antennas, mirrors, cables, etc*) from the plasma during standard / off-normal event

PFC design requirement:

- Absorb **heat fluxes** in the range of **several tens of MW/m²** up to **3 seconds**
- Withstand large electro-magnetic forces consequent to disruptions (*sudden loss of plasma control < 1 ms*) with **stresses** in the range **~500+ MPa locally**
- **PFC should be metallic** (*no carbon/graphite is allowed*) and change of phase (*erosion, melting, plastic deformation, etc*) should be strongly avoided

PFC design constraints:

- PFC should be **non-ferromagnetic**
- PFC should be compatible with high vacuum (**$10^{-6} < P < 1$ Pa**)
- PFC should be compatible with high temperature operation (**up to 500°C**)
- PFC will not be (actively) cooled
- **Manufacturability**
- **Price**

PFC denomination and dimensions

- 1) IWL: inner wall limiter
- 2) IDB: inner divertor baffle
- 3) IVT: inner vertical target
- 4) IDF: inner divertor floor
- 5) ODF: outer divertor floor
- 6) OVT: outer vertical target
- 7) ODB: outer divertor baffle
- 8) PSPP: passive stabilization plate protection
- 9) OHP: outer horizontal plate
- 10) OWL: outer wall limiters
- 11) OBP: outer bridge protection

Choice of material

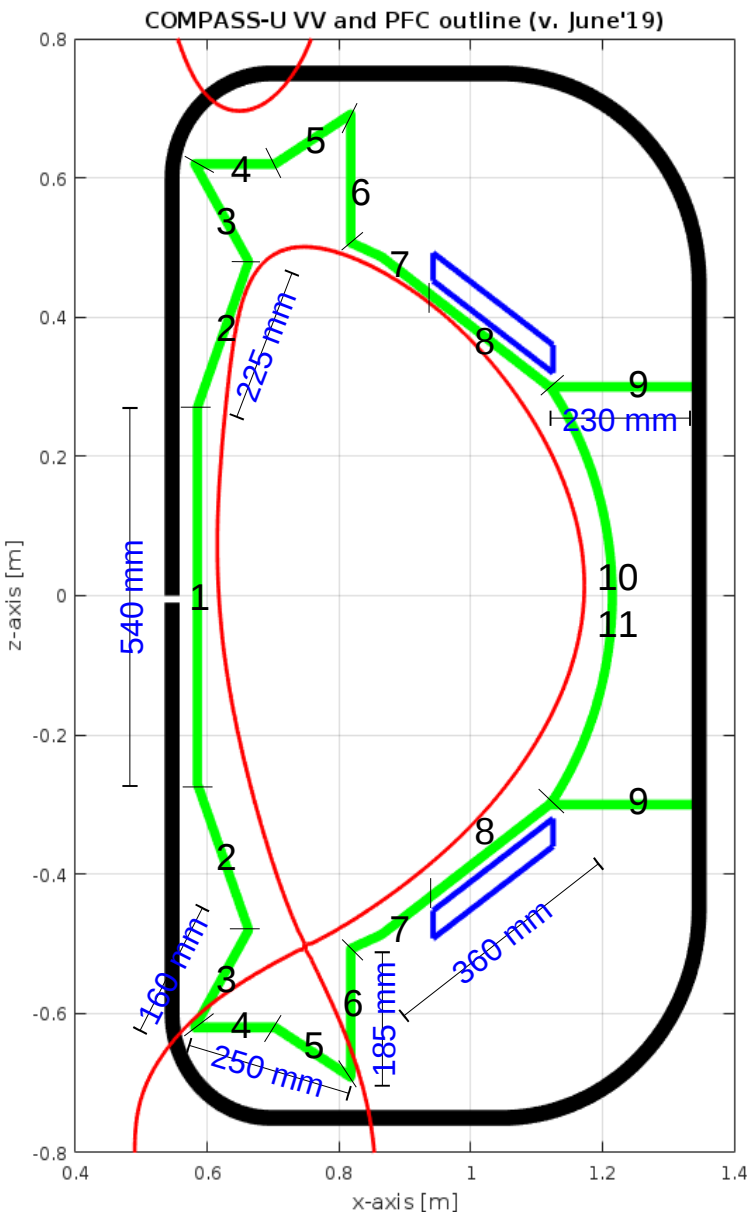
W or TZM or Mo as PFC:

- high melting point → HHF regions
- low electrical resistivity → large currents → large forces

Inconel⁷¹⁸ mainly as PFC with W-coating (or not)

Inconel⁶²⁵ for support structures

- high yield strength, especially at 500°C
- larger electrical resistivity → low forces
- low melting point



- | | |
|----------------|--|
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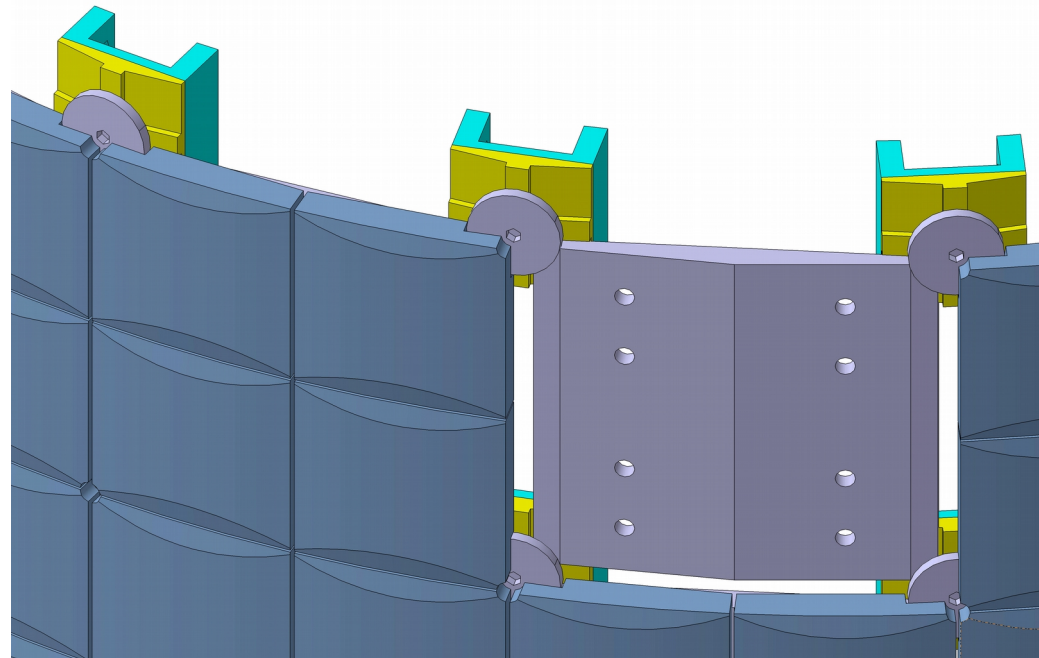
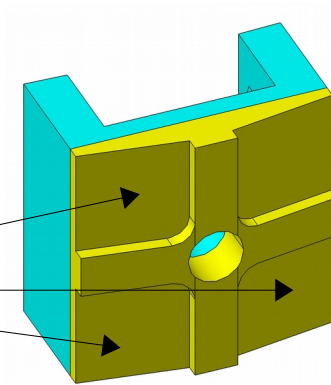
Inner Wall Limiter

– design v.01 –

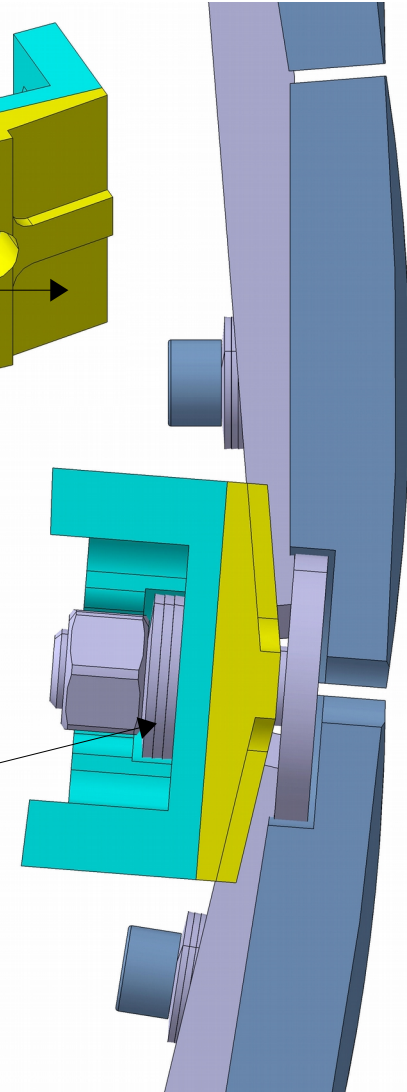
W/Mo/TZM tiles fixed to an **inconel plate**, which is fixed through **U-shape brackets** at its 4 corners

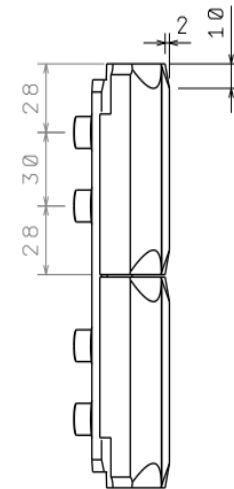
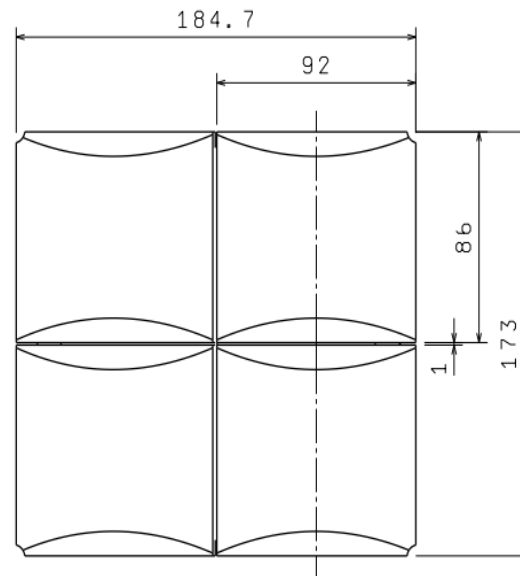
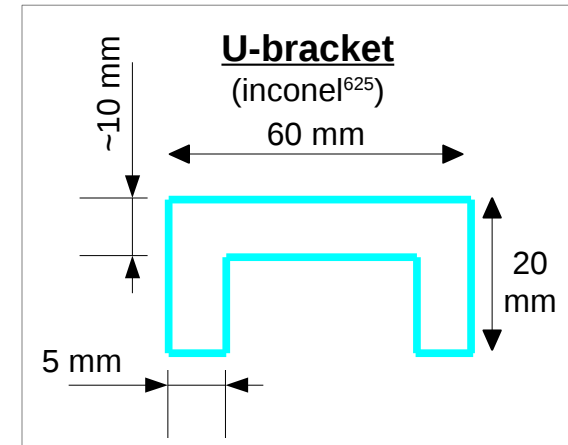
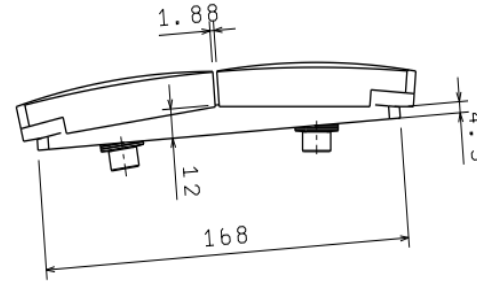
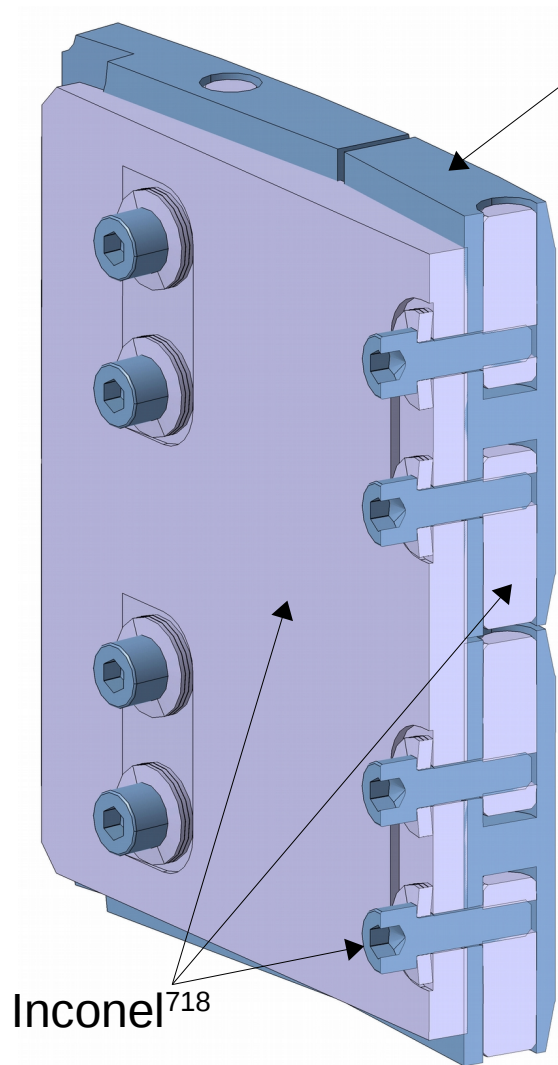
→ electrical insulation needed on some parts
(3 out of 4 corners of inconel plate and of the yellow **sloped washer**)

→ Technology preferred: alumina (Al_2O_3) coating



Belleville washers
(inconel??)

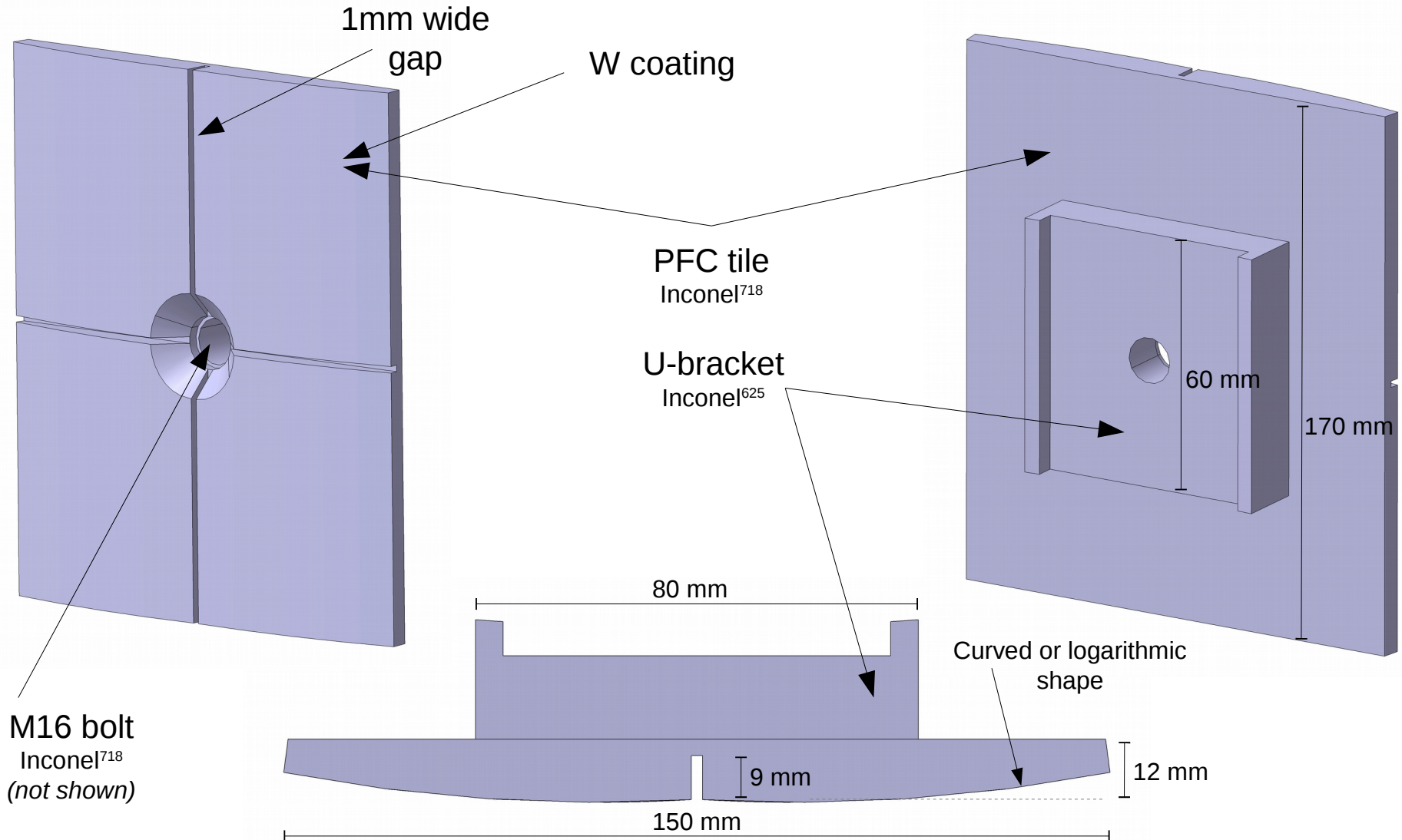




Elements	PFC	Material	~Number	~size [mm]	Note
Tiles	IWL v1	W <u>or</u> Mo <u>or</u> TZM	240	85x90x20	Front face shaping (logarithmic or circular + chamfer) + pockets for pins
U-brackets	IWL v1	Inconel ⁶²⁵	80	60x60x20	5mm thick legs to be welded to VV
Slope washers	IWL v1	Inconel ⁶²⁵	80	60x60x5	Machining + Al ₂ O ₃ coating
M12 bolts	IWL v1	Inconel ⁷¹⁸	80		
Belleville washers	IWL v1	Inconel ^{???}	n*80		
Baseplates	IWL v1	Inconel ⁷¹⁸	60	170x160x15	
M8 bolts	IWL v1	Inconel ⁷¹⁸	480		
pins	IWL v1	Inconel ⁷¹⁸	480	TDB	

Inner Wall Limiter

– design v.02 –



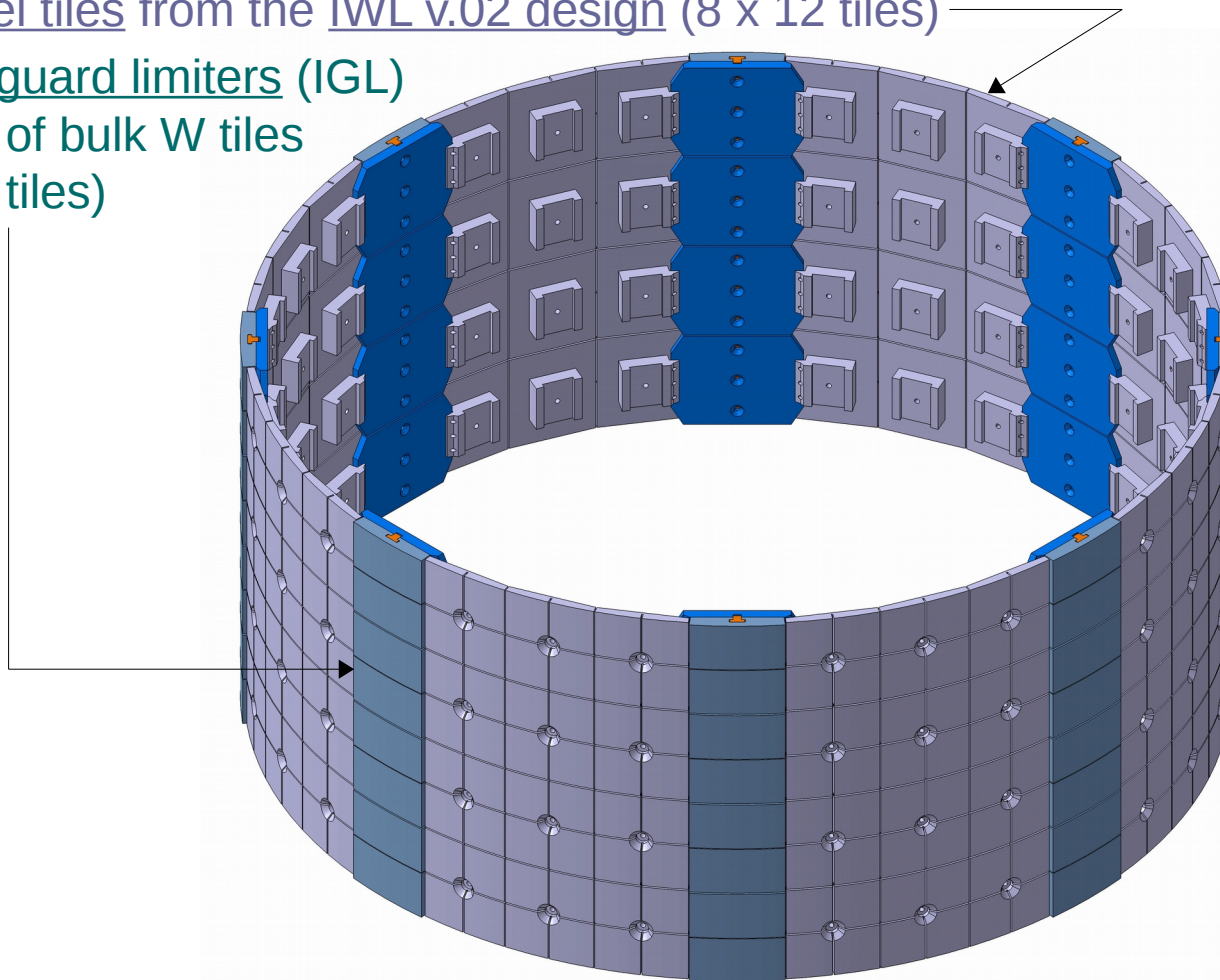
Elements	PFC	Material	~Number	~size [mm]	Note
Tiles	IWL v2	W coating on Inconel ⁷¹⁸	72	170x150x12	Front face shaping (logarithmic or circular + chamfer)
U-brackets	IWL v2	Inconel ⁶²⁵	72	80x60x20	5mm thick legs to be welded to VV and 13 mm thick base (to support the tile) + Precise machining for alignment
M16 bolts	IWL v2	Inconel ⁷¹⁸	72		Flat head
Belleville washers	IWL v2	Inconel ^{???}	n*72		

Inner Wall Limiter

– design v.03 –

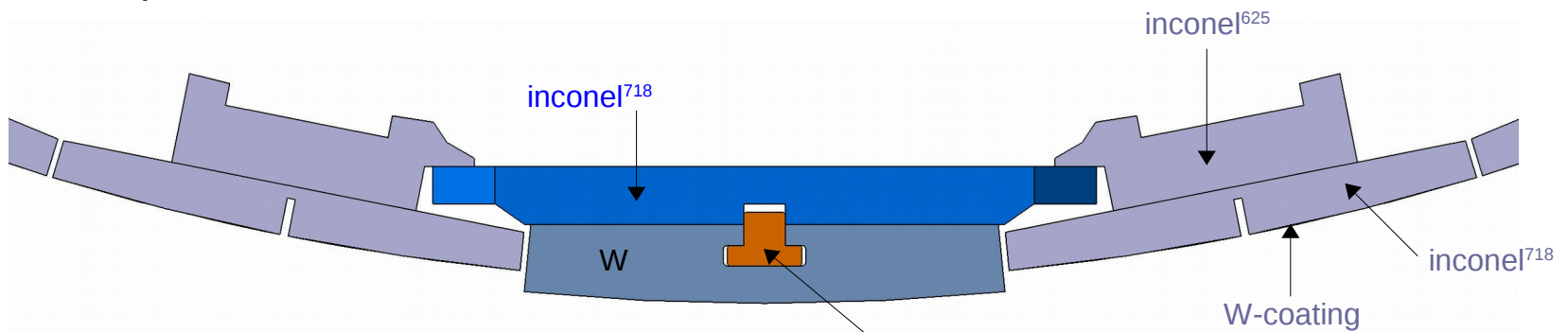
IWL v.03 concept is a mixture of:

- Inconel tiles from the IWL v.02 design (8 x 12 tiles)
- Inner guard limiters (IGL) made of bulk W tiles (8 x 8 tiles)

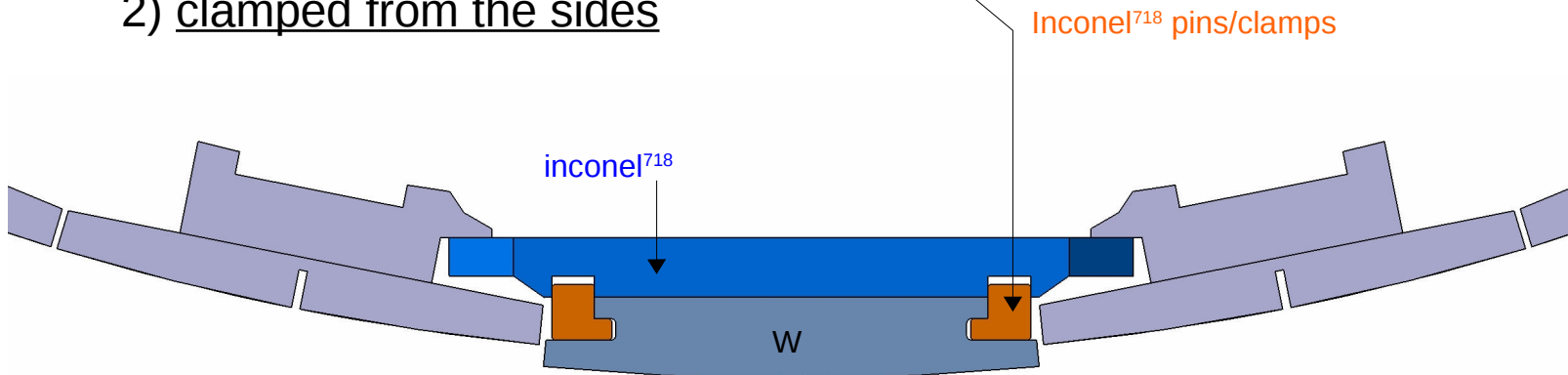


- Bulk W tiles are attached by pair to an inconel⁷¹⁸ backplate
- Two concepts of attachment to the back plate:

1) from the center

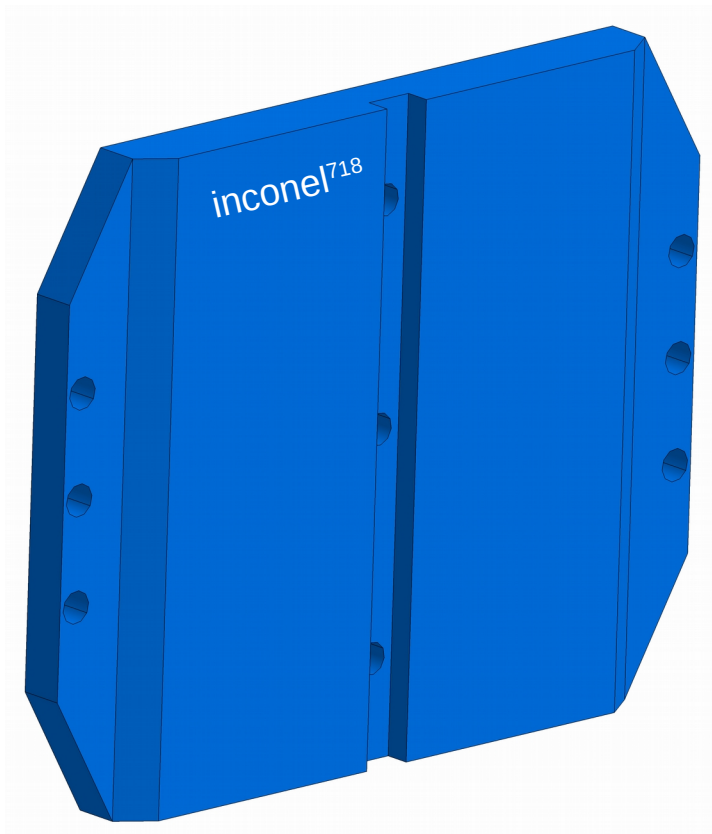


2) clamped from the sides



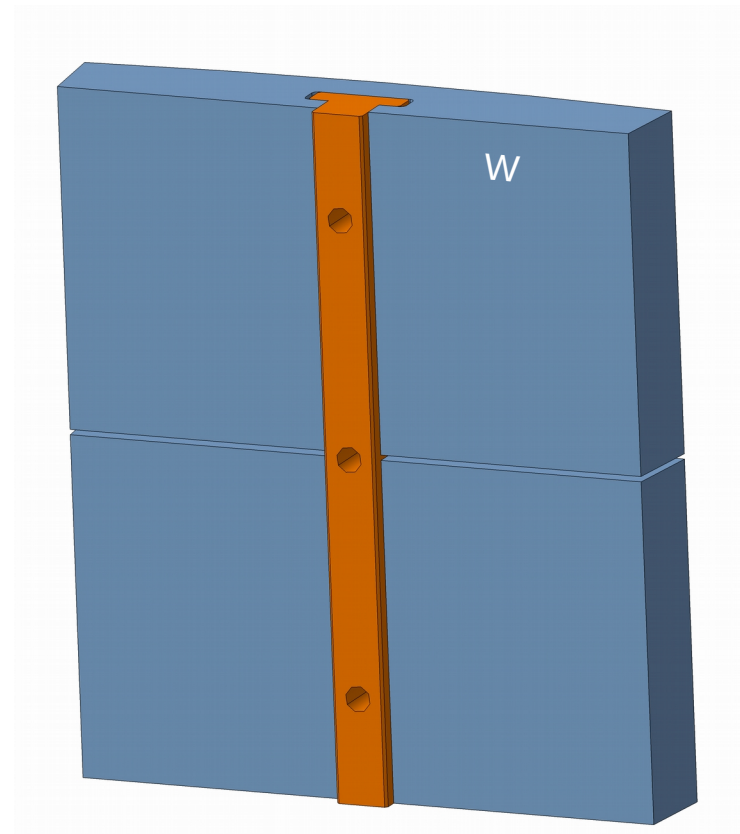
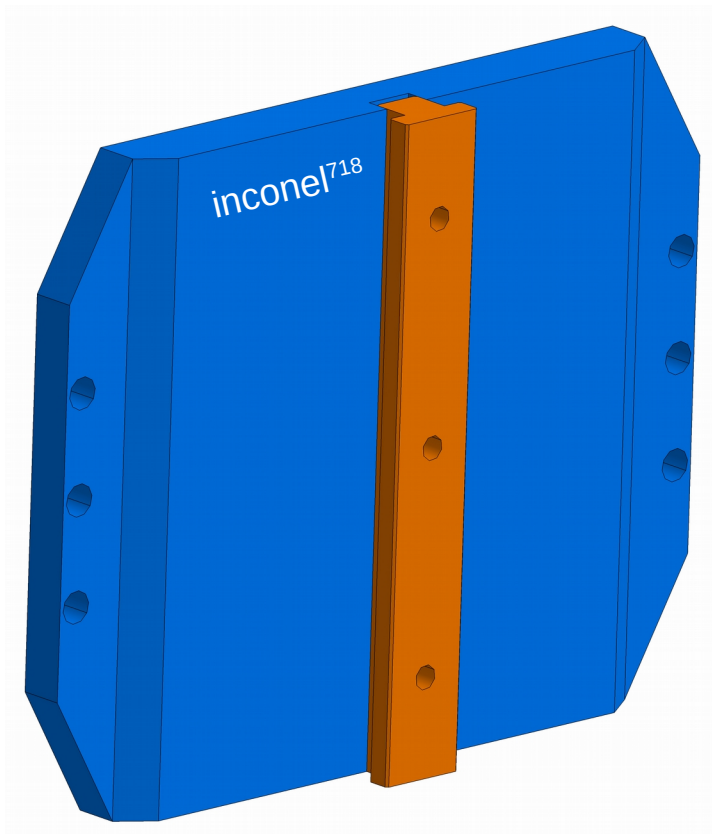
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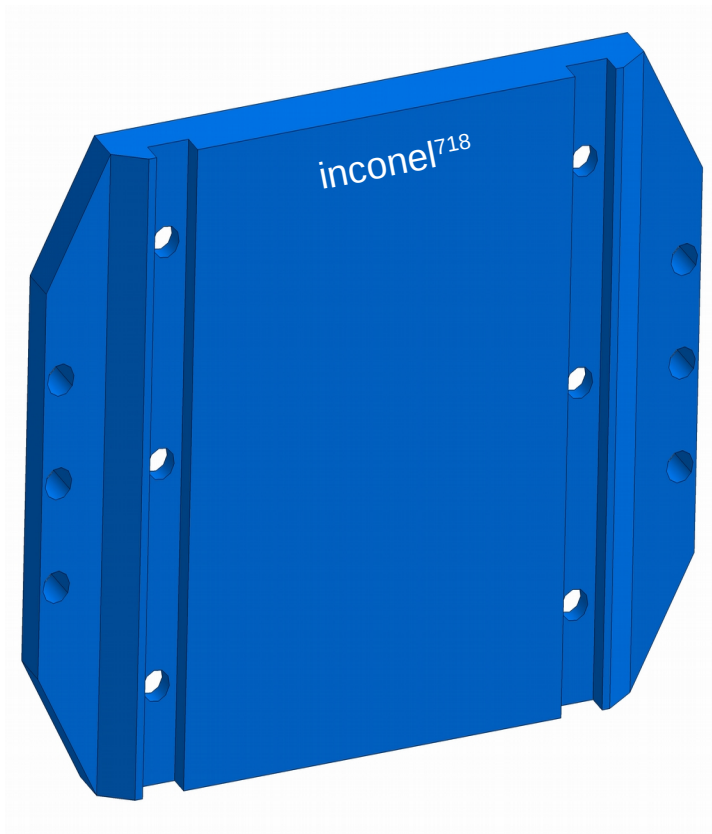
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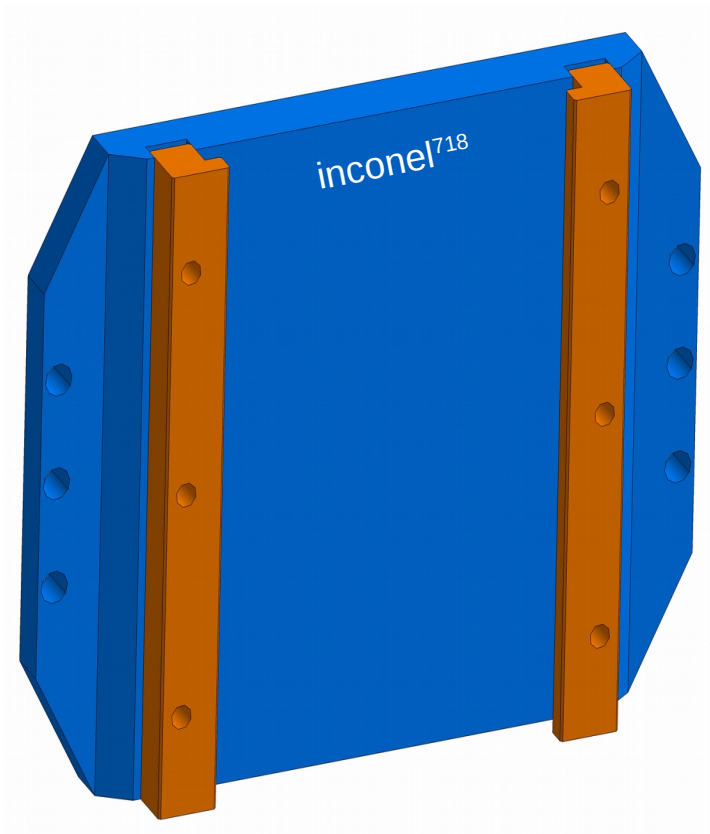
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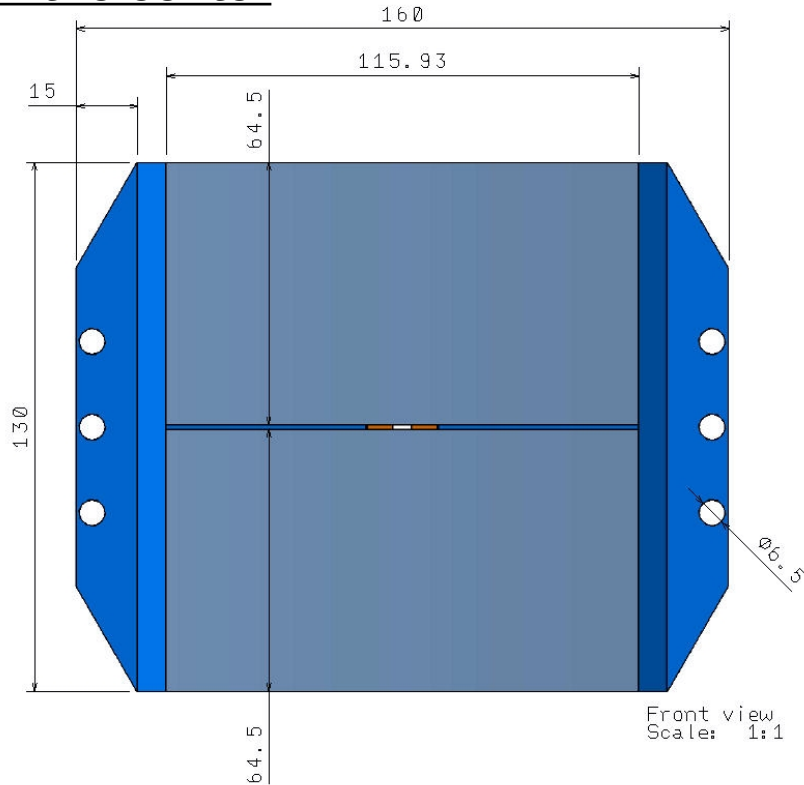


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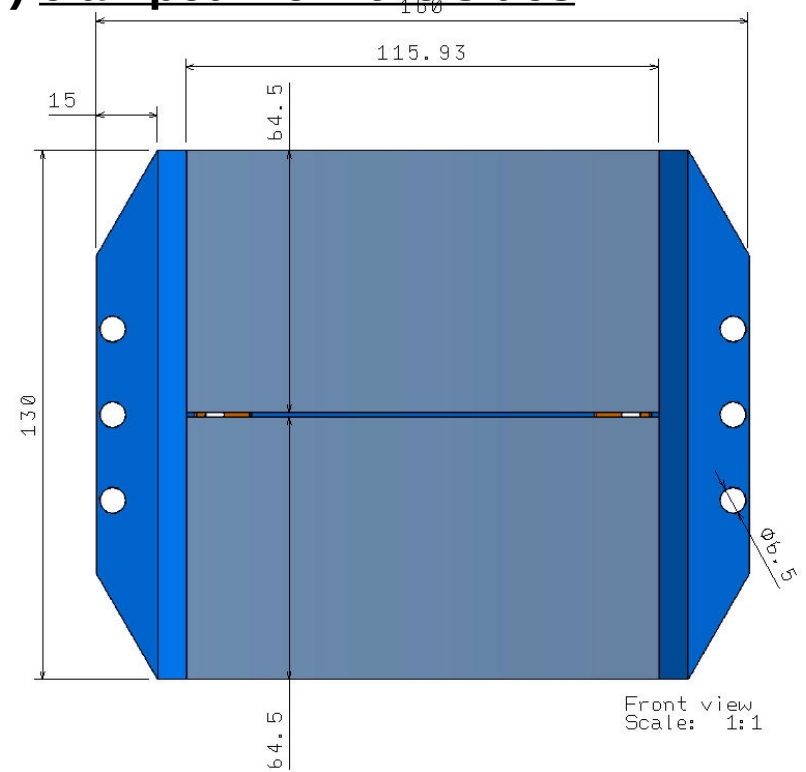
2) clamped from the sides



1) from the center



2) clamped from the sides



Elements	PFC	Material	~Number	~size [mm]	Note
Tiles	IWL v3	W coating on inconel ⁷¹⁸	96	130x115x12	Front face shaping (logarithmic or circular + chamfer)
IGL	IWL v3.1	W	64	115x65x19	Central pocket for fixation Side grooves for fixation ----- Front face shaping (logarithmic or circular + chamfer)
	IWL v3.2	W	64	115x65x19	
Backplates	IWL v3	Inconel ⁷¹⁸	32	160x130x14	
Pins / Clamps	IWL v3.1	Inconel ⁷¹⁸	32	18x13x130	
	IWL v3.2	Inconel ⁷¹⁸	64	14x13x130	
U-brackets	IWL v3	Inconel ⁶²⁵	96 (32 straight + 64 with legs)	50x50x20	5mm thick legs to be welded to VV and 13 mm thick base (to support the tile) + Precise machining for alignment
M16 bolts	IWL v3	Inconel ⁷¹⁸	96		Flat head
M6 bolts	IWL v3.1	Inconel ⁷¹⁸	288		
	IWL v3.2	Inconel ⁷¹⁸	384		

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